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**Isotopic Pennies Experiment**

**Objective**: To simulate the determination of the relative abundance of isotopes in a sample.

**Introduction:**

In this lab, you will be using U.S. Mint pennies to measure the relative abundance of an isotope in an unknown sample. After remaining largely unchanged since the first release in 1909, the mass of the Lincoln penny lost a full 20% in 1982! The change was a money saving measure. Less expensive and lower density zinc was substituted for some of the original copper. Copper prices had risen so much that the copper in a penny was worth more than one cent. The pre-1982 pennies were 95% copper and 5% zinc. Current pennies are 97.6% zinc, which is then coated with a thin layer of copper (2.4%).

Pennies with different chemical compositions have different masses. In this activity, a mixture of pre- and post-1982 pennies will represent the naturally occurring mixture of two isotopes of the imaginary element “coinium.” The pennies will allow you to learn one way that scientists can determine the relative amounts of different isotopes present in a sample of an element.

You will be given a sealed container that holds a mixture of ten pre- and post-1982 pennies. Your container might hold any particular combination of the two “isotopes.” Your task is to determine the isotopic composition of the element “coinium” ***without*** opening the container.

To illustrate how this is done, we can consider a mixture of our two isotopes of “coinium.” If your container (film canister) contains 9 pre-1982 pennies and one post-1982 penny, it would have a mass of 9 pre- PLUS 1 post-1982 pennies. We would mathematically represent the TOTAL MASS of your canister to be:

TOTAL MASS = (# of pre-1982 pennies x mass of one pre- penny) + (# of post-1982 pennies x mass of one post- penny)  
  
Since we know that there are ten pennies in the container, we can say that:

**χ = number of pre- pennies** and **(10 – χ) = number of post- pennies**  
  
Combine these two equations to solve in algebraic terms:

**TOTAL MASS = (χ x mass of one pre- penny) + ((10 – χ) x mass of one post- penny)**

**Materials:**

* Sealed container of 10 pennies
* Stack of 10 pre-1982 pennies
* Stack of 10 post-1982 pennies
* Weighing boat
* Balance

**Procedure:**

1. Record the identification number of your sealed film canister containing “coinium” on your data sheet.
2. Find the mass of an average pre-1982 penny by accurately weighing 10 on the balance and dividing to determine the mass of one. Record this value on your data sheet.
3. Find the mass of an average post-1982 penny by accurately weighing 10 on the balance and dividing to determine the mass of one. Record this value on your data sheet.
4. Find the mass of an empty canister. Then find the mass of the sealed canister of pennies.
5. Subtract to determine the mass of the ten pennies in YOUR canister.
6. Calculate the value of **χ**.
7. Calculate the percent composition of the element “coinium” from your data.

**Data Sheet for Isotopic Pennies Lab**

Code number of sealed container:\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |
| --- | --- | --- | --- |
| **PROCEDURAL STEP** | **MEASUREMENT** | **PROCEDURAL STEP** | **MEASUREMENT** |
| 1. Mass of 10 pre-1982 pennies |  | 7. Mass of 10 mixed pennies in the sealed container |  |
| 2. Average mass of 1 pre-1982 penny |  | 8. Calculate value of **χ** |  |
| 3. Mass of 10 post-1982 pennies |  | 9. # of pre-1982 pennies |  |
| 4. Average mass of 1 post-1982 penny |  | 10. # of post-1982 pennies |  |
| 5. Mass of sealed canister of 10 pennies |  | 11. Percent composition of “coinium” **Pre-1982** |  |
| 6. Mass of empty canister |  | 12. Percent composition of “coinium” **Post-1982** |  |

**Space for Calculations (show your work):**

**Post-Lab Questions:**

1. What physical property of the element “coinium” is different in its pre- and post- forms?

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1. In what ways is the penny mixture a good analogy for actual element isotopes? How is it misleading or incorrect?  
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EXAMPLE PROBLEM: Now calculate the average atomic mass of an element by using the concept of weighted average. Here is an example for an actual isotopic mixture. The unit **“amu”** is used to describe the mass (instead of grams or some other unit of measure for now). It stands for **atomic mass unit** and is based on the carbon–12 atom.

1. Naturally occurring copper consists of 69.1% copper – 63 and 30.9% copper – 65. Calculate the molar mass (in amus) of naturally occurring copper.
2. Almost all boron atoms are found in two forms: boron-10 and boron-11. Both isotopes behave alike chemically and are useful in fireworks (green color), in the antiseptic boric acid, and in heat-resistant glass. However, only boron-10 is useful as a control material in nuclear reactors, as a radiation shield, and in instruments used to detect neutrons. If the average atomic mass of boron is 10.81 amu, which boron isotope must be more abundant in nature? How do you know?